Predator Density and Size Structure in Different Habitats of Toledo Bend Reservoir, with Implications for Increasing Stocked Largemouth Bass Survival

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Abstract: Texas Parks and Wildlife Department (TPWD) primarily stocks Florida largemouth bass (*Micropterus salmoides floridanus*; total length range 30 to 46 mm) to influence the genetic composition of existing populations or to supplement limited recruitment. These stockings have altered the genetic composition of largemouth bass populations; however, stockings often result in variable and low contributions to cohort abundance. Potential sources of stocked fish mortality include hauling stress, lack of prey and foraging success, and predation. Previous studies indicate that predation may be the largest immediate source of mortality with estimated losses of over 25% of all stocked fish within 12-h post stocking in a Texas reservoir. This study evaluated community structure, abundance, and size structure of potential predators in five different littoral habitat types including featureless banks, hydrilla (*Hydrilla verticillata*), timber-hydrilla, timber, and semi-terrestrial cover over an eight-month period. Littoral predator species densities and compositions changed across time, with higher overall densities observed in the spring and fall. Featureless habitats were the most dissimilar with respect to predator abundance. Habitats characterized by hydrilla had the highest largemouth bass densities in the spring and fall, but in summer months, largemouth bass densities were highest in semi-terrestrial habitat types. Spotted bass (*M. punctatus*), redbreast sunfish (*Lepomis auritus*), and longear sunfish (*L. megalotis*) exhibited a preference for featureless habitat types, while redear sunfish (*L. microlophus*) and spotted gar (*Lepisosteus oculatus*) preferred habitat dominated by timber. Stocking may be more effective in sites that contain fewer predators that prey on largemouth bass fingerlings at lesser rates or less efficiently as this study indicates that different fish assemblages exists between both habitat types and time.

Key words: Habitat, largemouth bass, stocking, spotted bass, redbreast, redear, spotted gar

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Largemouth bass (*Micropterus salmoides*) stockings have been shown to result in low returns with minimal contributions to cohort abundance (Ryan et al. 1998, Buckmeier and Betsill 2002, Hoffman and Bettoli 2005). Potential sources of mortality for stocked fish include hauling stress, poor prey availability, and predation. Previous studies in Texas discount hauling stress (Pitman and Gutreuter 1993, Buckmeier and Betsill 2002, Buckmeier et al. 2005) and feeding success (Buckmeier et al. 2005) as significant mortality sources. Predation is likely the most significant mortality source of stocked fish (Wahl and Stein 1989, Szendrey and Wahl 1996, Schlechte et al. 2005). Buckmeier et al. (2005) estimated that up to 27.5% of stocked largemouth bass fingerlings (30–46 mm TL; total length) were eaten within 12 hours in a Texas reservoir.

To reduce predation, Texas Parks and Wildlife Department (TPWD) stocks largemouth bass into the most structurally complex inshore habitat available with at least 2 km between adjacent stocking locations (TPWD, Inland Fisheries Division, unpublished Fishery Assessment Procedures, revised 2005). Predation success for largemouth bass (Savino and Stein 1982) and spotted gar (*Lepisosteus oculatus*) (Ostrand et al. 2004) has been reduced in complex habitats, likely due to the creation of visual and physical barriers. Habitat complexity often influences not only fish density and associated assemblages, but also affects foraging behavior and preferences (Schramm and Zale 1985). Predator composition and density within habitat are spatially and temporally dynamic. Many studies have documented seasonal habitat use; however, most have focused on a single species or the interactions of a few similar species (Schlagenhaft and Murphy 1985, Mesing and Wicker 1986, Snedden et al. 1999, Weller and Winter 2001, Paukert and Willis 2002, Daugherty and Sutton 2005). Studies to evaluate seasonal use of various habitat types and interactions of fish assemblages have not been conducted in Texas reservoirs for improving largemouth bass stocking success. The purpose of this study was to evaluate the size structure and relative densities of predators that could potentially prey on stocked fingerling largemouth bass in selected habitat types. Knowledge of seasonal habitat use by predators may aid managers in determining when and where stocked largemouth bass will have reduced predation risk.

Study Area

Toledo Bend Reservoir is an impoundment of the Sabine River in eastern Texas/western Louisiana. The reservoir was impounded in 1966 and at conservation pool (52.4 m above mean sea level) has a surface area of 64,990 ha, a shoreline of 1,920 km, and a mean depth of 6.0 m. Water level fluctuations average 1.5 m annually. The reservoir is eutrophic with a mean Trophic State Index chl-*a* of 48.4 and secchi disc readings exceeding 2.0 m (Texas Commission on Environmental Quality 2008). The majority of aquatic habitat consists of submerged vegetation, primarily hydrilla (*Hydrilla verticillata*), and standing timber. Substrate consists of sand, clay, and rocky bottoms. Most of the land surrounding the reservoir is used for timber, agriculture, or residential development.

Methods

We created five habitat categories (hydrilla, timber, timber-hydrilla, featureless, and semi-terrestrial) and selected six sites within each category. Semi-terrestrial sites were characterized by emergent vegetation consisting primarily of spikerush (*Eleocharis* spp.), bulrush (Scirpus spp.), and torpedo grass (*Panicum repens*). Study sites were limited to the littoral zone (< 1.5 m), were in the southern portion of the reservoir within Texas waters, and were randomly distributed. To be selected, study sites had to have 100 m of contiguous habitat within a single category and be at least 1.0 km from another study site. The majority of sites were sampled throughout the study; however, two sites were relocated due to water level fluctuations and changes in habitat characteristics.

Predatory fishes were collected at night (no earlier than 30 minutes after sunset) using pulsed direct current from a 5.0 GPP boom-mounted boat electrofisher (Smith-Root, Inc., Vancouver, Washington; 4.5–5.0 amps current) while following the shoreline for each 100 m site. Dumont and Dennis (1997) found that night electrofishing provided higher catch rates and caught larger specimens than day electrofishing. Pierce et al. (2001) found that night electrofishing produced significantly greater species richness measures than did daytime sampling while Buckmeier et al. (2005) found that daytime electrofishing yielded few predatory fish. Sampling personnel remained the same throughout the study period to avoid sampling selectivity or bias. Predators were defined as fish capable of consuming fingerling largemouth bass < 40 mm and included all gar (*Lepisosteus* spp.), freshwater drum (*Aplondinotus grunniens*), sunfish (*Lepomis* spp.) > 90 mm, and all black bass (*Micropterus* spp.) > 70 mm (Buckmeier et al. 2005). Catfish (*Ictalurus* spp.) were not identified as potential predators because they did not consume stocked largemouth bass during the course of the Buckmeier et al. (2005) study.

We sampled monthly (i.e., April–November) with at least two weeks between sampling events to help gain independence. All predator fish encountered were collected, counted, measured (TL) to the nearest millimeter, and released. A suite of multivariate techniques was used to examine the data using Primer-e, version 6.1.10 (Clarke and Warwick 2001). We examined densities of predatory species across habitats in each month by computing Bray-Curtis similarity indices (Bray and Curtis 1957) using untransformed catch-per-unit-effort (CPUE) data. Indices were then ranked and tested using a one-way analysis of similarity (ANOSIM). When the analysis suggested a significant global test of our hypothesis ($\alpha = 0.05$), we used pairwise tests to compare all habitat types. We followed Clarke and Warwick's (2001) recommendation of treating pairwise tests pragmatically rather than strictly adhering to a pairwise correction such as a Bonferroni adjustment. When habitat communities differed based on the pairwise comparisons, we ascertained which species were important in differentiating the habitats by examining mean CPUE of each species. We also examined species composition across months. For each month, all six sites for each habitat type were combined into a mean CPUE. We followed the same process of analysis as was done for the untransformed CPUE data.

To explore potential changes in size structure across habitat types and months, we computed the mean length of each species at each sample site. We then used a two-way analysis of variance (MIXED; SAS Institute 1990), with habitat type as the factor of interest and month as a blocking factor. When an overall test of model significance suggested a significant effect of habitat type, we then conducted pairwise comparisons on the least-squares means. To control for the Type I error associated with multiple comparisons, we used the Adjust=SIMULATE option.

Results

A total of 6,590 fish were collected from 233 sites over the 8-month study period. Average electrofishing pedal time for each 100-m study transect was 3.9 min (range 2.3–8.3 min). Mean conductivity was 153 µS/cm.

Predator Density

Our global tests using ANOSIM were significant for each month: April, June–September ($\alpha = 0.001$); May and October ($\alpha = 0.002$); November ($\alpha = 0.003$). Pairwise comparisons of habitat types within each month indicated featureless habitat was significantly different ($P < 0.05$) from all other habitat types from April through August and different from all habitats but timber ($P = 0.065$) in September (Figure 1). Featureless habitat had many fewer largemouth bass, redear sunfish (*Lepomis microlophus*), and spotted gar, yet many more spotted bass (*M. punctatus*), redbreast sunfish (*L. auritus*), and longear sunfish (*L. megalotis*). Featureless habitat was different from hydrilla ($P = 0.002$) and timber ($P =$

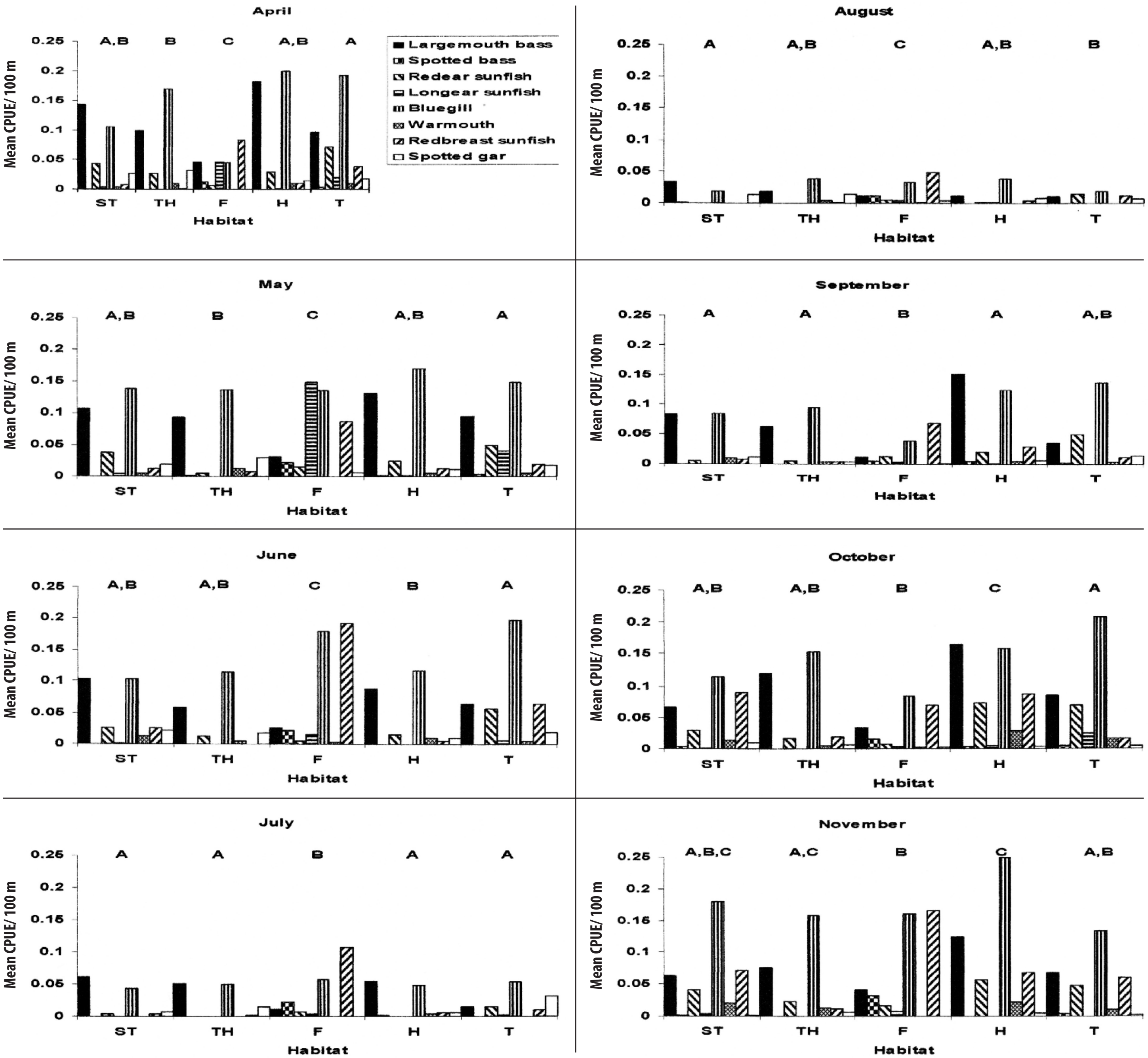

Figure 1. Mean catch-per-unit-effort (CPUE) for largemouth bass, spotted bass, redear sunfish, longear sunfish, bluegill, warmouth, redbreast sunfish, and spotted gar for semi-terrestrial (ST), timber-hydrilla (TH), featureless (F), hydrilla (H), and timber (T) habitat types April–November. Habitat types with the same letter (A, B, C) had similar ($P > 0.05$) fish community CPUE.

0.048) in October and different from hydrilla, timber-hydrilla, and timber ($P < 0.05$) in November due to fewer largemouth bass and redear sunfish but more spotted bass and redbreast sunfish. Timber habitat differed ($P < 0.05$) from other habitat types (timber-hydrilla (April and May), hydrilla (June, October, and November), and semi-terrestrial (August) due to lower abundances of largemouth bass and higher abundances of redbreast sunfish, redear sunfish, and bluegill (*L. macrochirus*). Hydrilla was different ($P < 0.05$) from all other habitat types in October primarily due to high largemouth bass densities.

Monthly Effects

The global ANOSIM test was significant ($\alpha = 0.001$), suggesting that the community structure within habitats changed with time

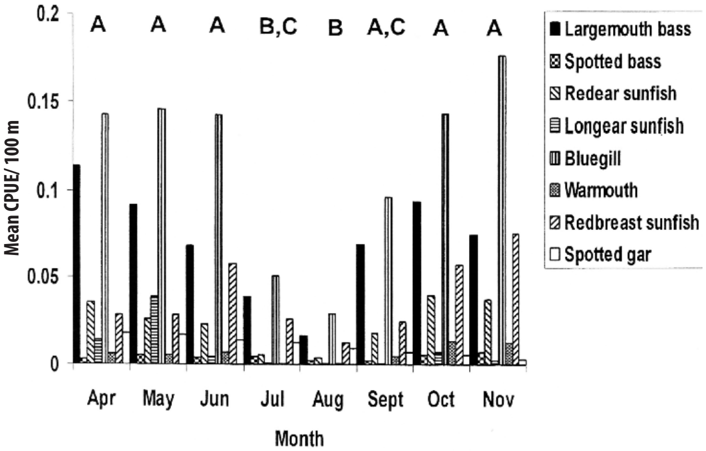

Figure 2. Mean catch-per-unit-effort (CPUE) for largemouth bass, spotted bass, redear sunfish, longear sunfish, bluegill, warmouth, redbreast sunfish, and spotted gar for April–November. Months with the same letter (A, B, C) had similar ($P > 0.05$) fish community CPUE.

(Figure 2). Spring and fall months were similar (April–June and October–November; $P > 0.05$) characterized by high abundances of largemouth bass and bluegill. Except for the transition into and out of summer (June–July ($P = 0.032$) and August–September ($P = 0.016$), adjacent months were not statistically different ($P > 0.05$). July and August were similar ($P = 0.198$) and had overall lower abundances of predators for any given month, primarily having fewer largemouth bass and bluegill present.

Size Structure

We found that we had several species with sufficient data to examine changes in size structure (redbreast, bluegill, redear sunfish, and largemouth bass). Other species [spotted bass, longear sunfish, warmouth (*Lepomis gulosus*), spotted sunfish (*L. punctatus*), freshwater drum and spotted gar] were found in limited habitats and numbers and were excluded from these analyses. Bluegill was the only species that displayed significant habitat segregation based on length. Larger bluegill were found in timber habitat (mean = 120.9 mm), as compared to hydrilla (114.0 mm; $P = 0.004$), timber / hydrilla (113.9 mm; $P = 0.003$), featureless (113.3 mm; $P = 0.002$), and semi-terrestrial (109.8 mm; $P < 0.001$) habitat.

Discussion

In our study, fish assemblage differences between habitat types were driven primarily by the abundance of largemouth bass, spotted bass, redear sunfish, redbreast sunfish, and to a lesser extent spotted gar, all of which have been documented to exhibit specific habitat preferences (Sammons and Bettoli 1999, Snedden et al. 1999, Barwick 2004). Our featureless habitat type, characterized by a lack of vegetation and woody debris, was the most structurally simple habitat type evaluated and was found to be the most dissimilar habitat type due to high abundances of redbreast sunfish and spotted bass. Complex habitat (e.g., increased vegetative cover or woody debris) often contains greater species richness and density (Benson and Magnuson 1992, Hatzenbeler et al. 2000, Barwick 2004), and our study found similar results.

Our study observed the lowest fish densities during summer months. This could likely be attributed to fish seeking refuge from higher water temperatures by migrating to deeper water. Seasonal differences in fish abundance especially during summer months when water temperatures are highest coincides with other studies that have found temperature to influence fish movement and habitat preferences (Hall and Werner 1977, Troutman et al. 2007).

Seasonally, largemouth bass were found to have the most notable change in density in relation to habitat type. Largemouth bass densities were highest in hydrilla habitats in both the spring and fall, but in summer, abundance was higher in semi-terrestrial habitat. Largemouth bass are known to exhibit seasonal habitat preference (Schlagenhaft and Murphy 1985, Barwick 2004). Largemouth bass may inhabit areas with suitable forage and less complexity for greater predation efficiency. Another explanation of the seasonal habitat differences is that largemouth bass may exhibit preferences for certain habitat types for spawning (Miller and Kramer 1971, Vogele and Rainwater 1975, Annett et al. 1996, Barwick 2004).

Sammons and Bettoli (1999) speculated that differential survival might have been the cause for observing a higher abundance of larger largemouth bass in nongravel (i.e., marginal) habitats in a Tennessee reservoir. Sammons and Bettoli further speculated that largemouth bass may move sometime after age-1 to more preferred habitat. However, fish spawned in marginal habitats may experience higher mortality rates, leading to faster growth of remaining fish and production of larger individuals due to decreased intraspecific species competition. Our study found no size differentiation between habitat types for largemouth bass, which may indicate a degree of site fidelity for all life stages.

Differences in electrofishing efficiency across habitat types were a concern. Sammons and Bettoli (1999) found that their electrofishing catch rates for black bass were different for individual species and habitat types, when if efficiency were to have been affected by habitat type all species would have been affected similarly. As with Sammons and Bettoli (1999) we found differences in individual species abundance in different habitats rather than observing similar change in electrofishing catch rates for all species (e.g., featureless habitat had high abundances of redbreast but low abundances of largemouth bass while hydrilla had the opposite). Our electrofishing CPUEs showed species specific preferences for habitat type, indicating that electrofishing even when efficiency is unknown remains a good indicator of species specific relative abundance.

Low abundance of largemouth bass in featureless habitat supports TPWD policy to stock largemouth bass in the most structurally complex littoral habitat available (i.e., largemouth bass prefer complex habitat). However, since TPWD conducts the majority of its stocking in June when predator abundance was high may impose significant predation risk to stocked fish, whereas if fish were stocked in July when predator abundance was lowest may decrease predation risk. We do not know if a specific habitat type (e.g., hydrilla, timber-hydrilla, semi-terrestrial, and timber) would yield higher survival of stocked fish at Toledo Bend Reservoir, but are confident that featureless habitat supports low densities of largemouth bass. This may be a result of largemouth bass avoiding featureless habitat for spawning, thus low densities of largemouth bass were observed. This study indicates potential predators are in high abundance in all habitat types including featureless habitat. However, if reduced predation is an overriding concern to increase survival of stocked fish, stocking may be more effective in sites that contain fewer predators that prey on largemouth bass fingerlings in lesser rates or less efficiently. Buckmeier et al. (2005) found that sunfish preyed on stocked largemouth bass 30 to 46 mm in low rates as compared to largemouth bass, which was found to consume most of the stocked fish that were found to be preyed upon. Our results indicate featureless habitat types have high abundances of sunfish and low abundances of largemouth bass. However, largemouth bass may have density-dependent interactions and decreased survival of both resident fish and stocked fish when habitat is limited or over exploited (Buynak and Mitchell 1999). Further research is needed to evaluate optimal size, timing, and location of largemouth bass stockings to reduce predation and increase survival of stocked largemouth bass.

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